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(54) **TOUCH WAKE FOR ELECTRONIC DEVICES**

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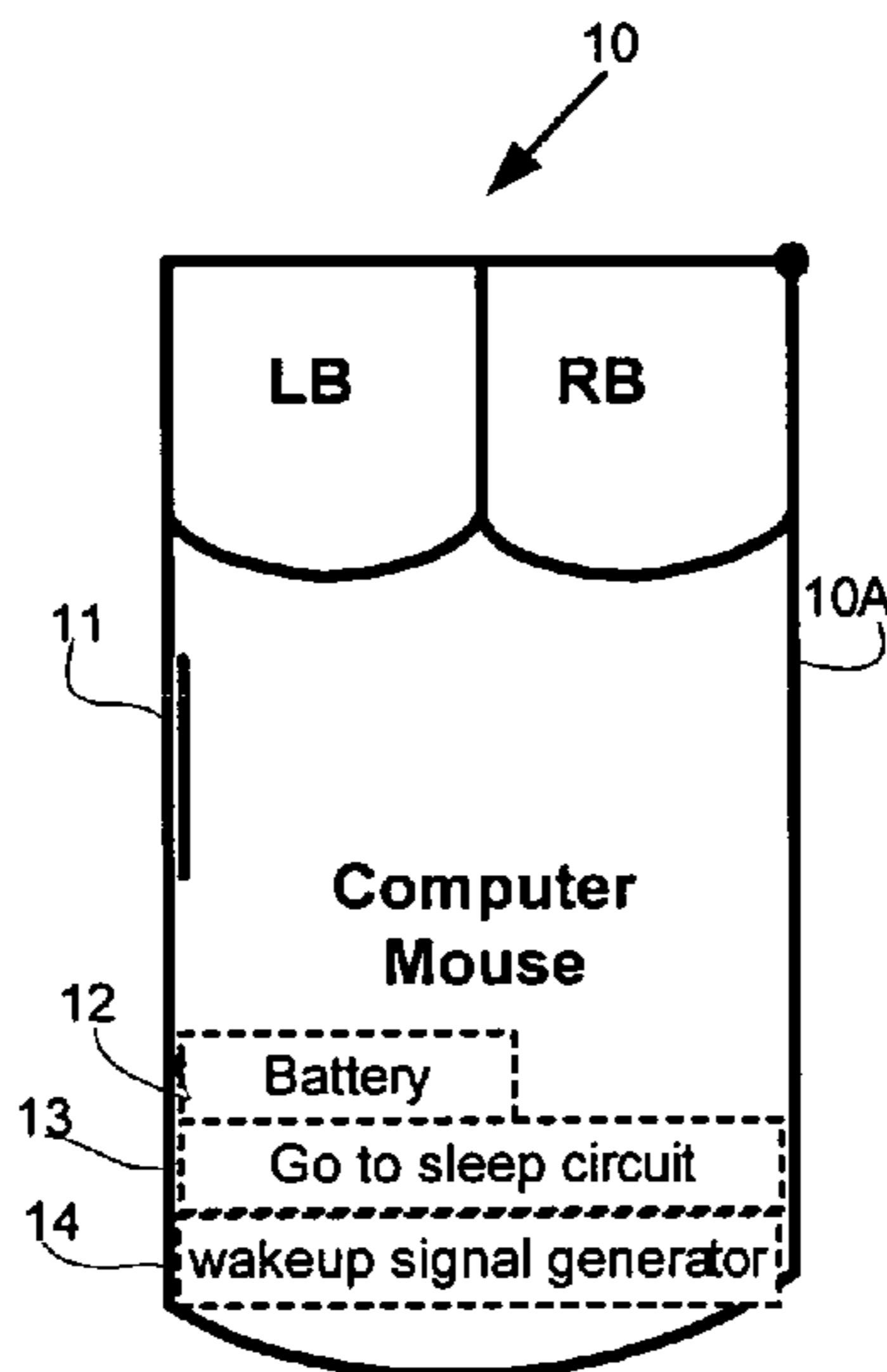
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(57) **ABSTRACT**

A system to generate a wakeup signal for a low power device: The system includes a capacitor, the capacitance of which changes when a user touches the device by placing a finger or hand near a certain location on the device. The capacitor is cyclically charged to a pre-established value and then discharged. The time required to charge and discharge the capacitor is a function of the capacitor size and thus, a function of whether or not the operator is touching the device. The number of charge-discharge cycles that occur in a certain period of time is counted. If the number is relatively small, it indicated that a user is touching the device and a wake signal is generated. If the number is relatively large, it means that the user is not touching the device and no wake signal is generated. Thus, in the embodiments shown, a wake signal is generated when the operator touches the device.

**18 Claims, 4 Drawing Sheets**



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# Figure 1

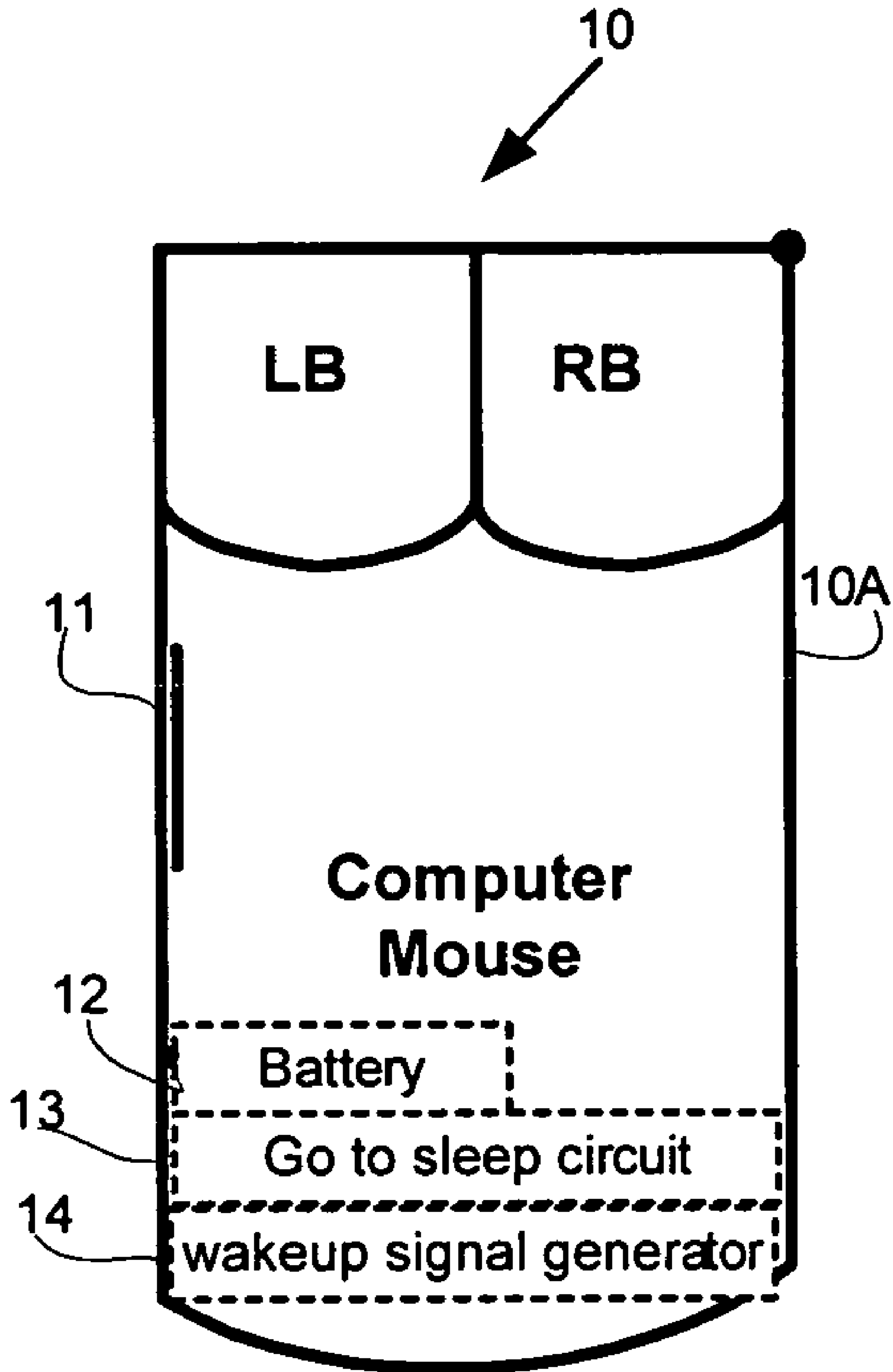




Figure 2A

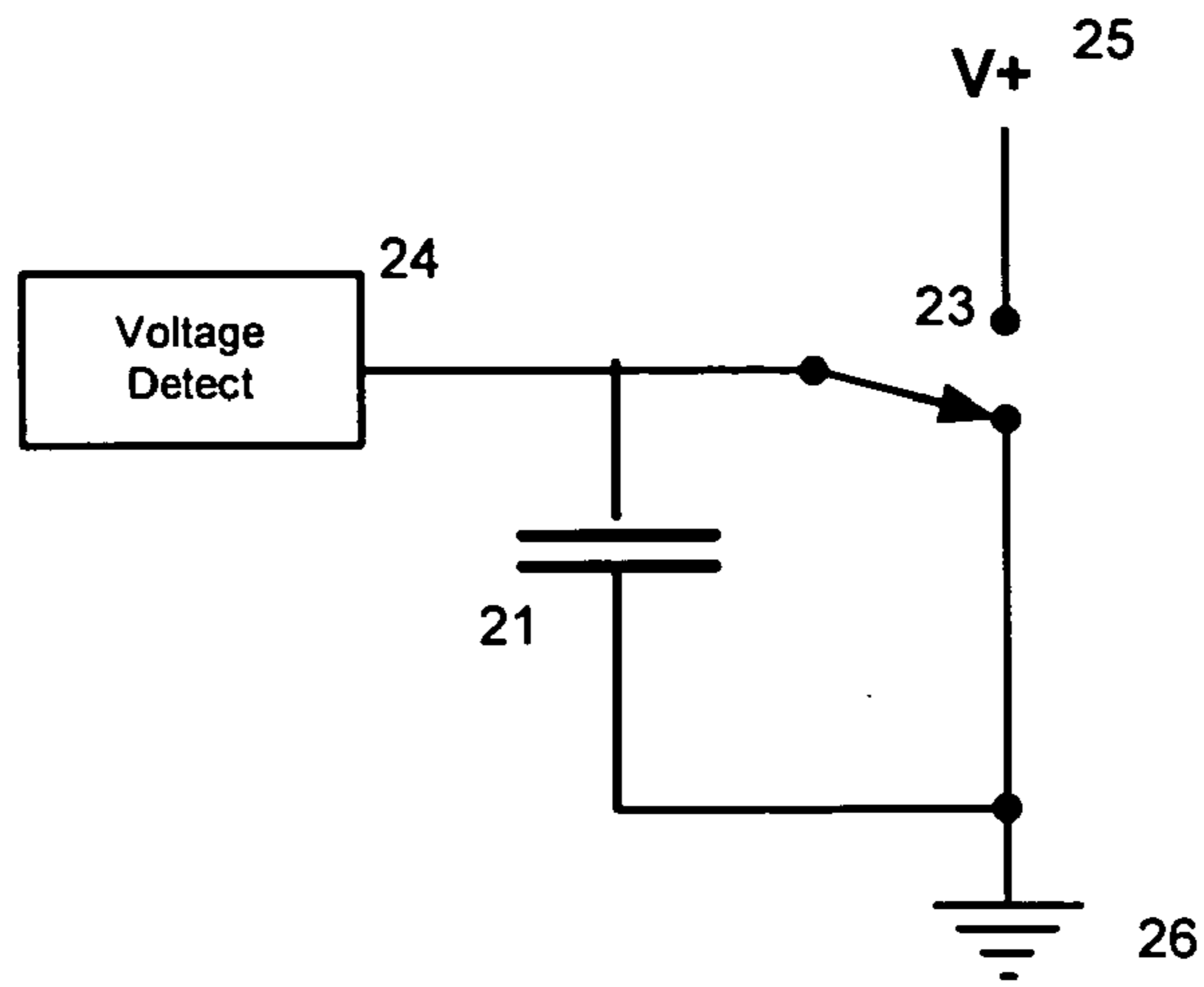


Figure 2B

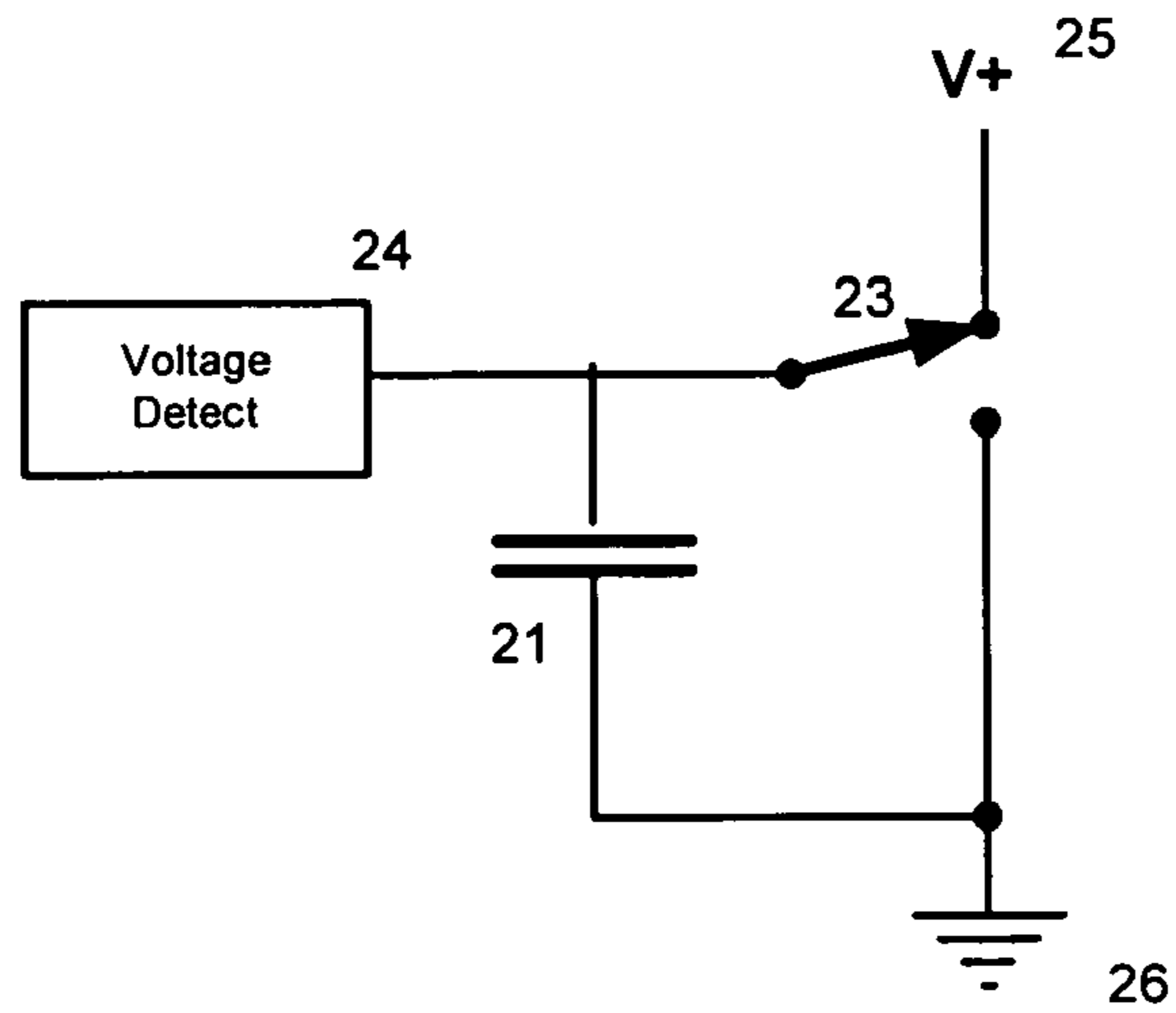


Figure 2C

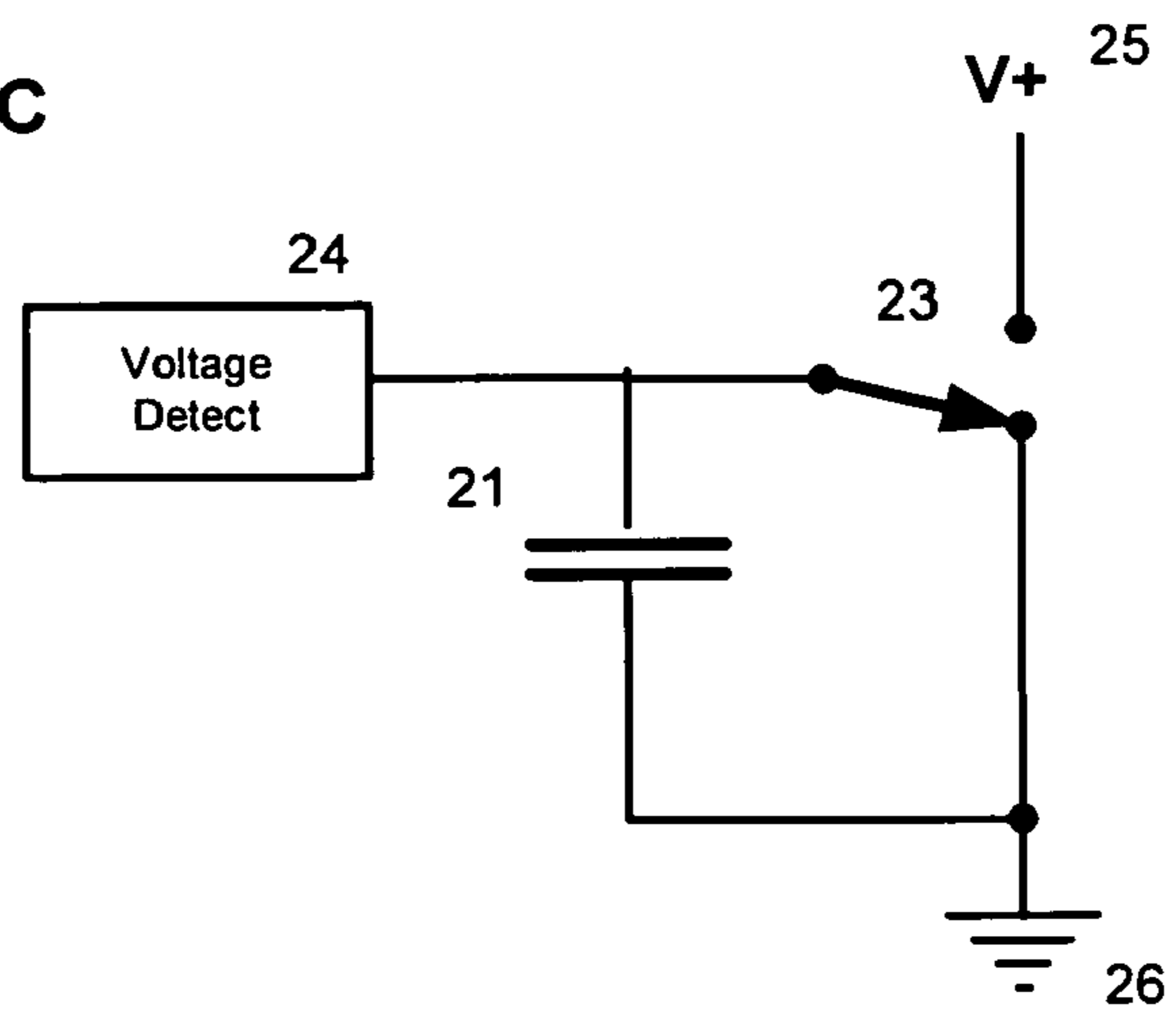




Figure 3

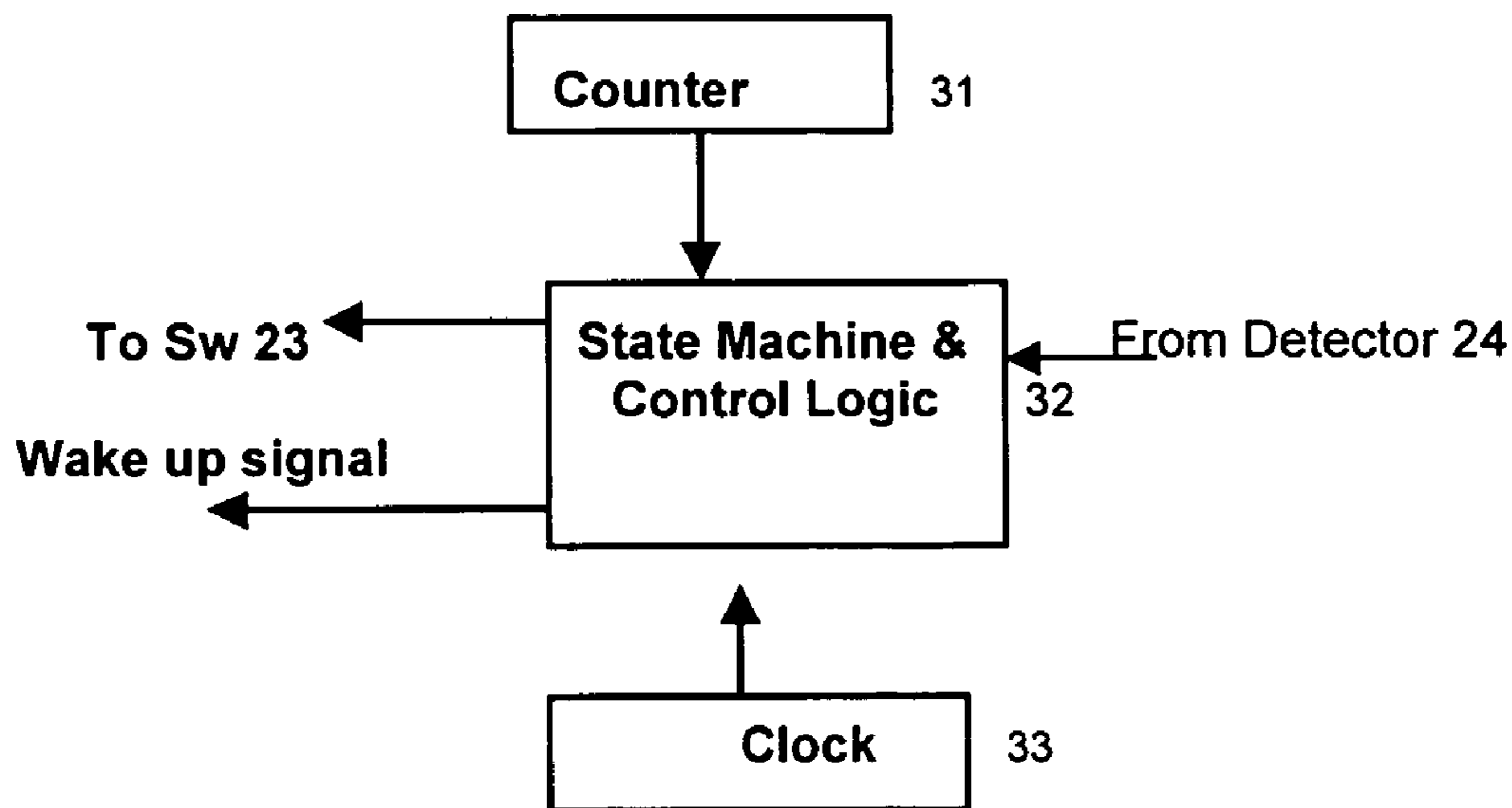
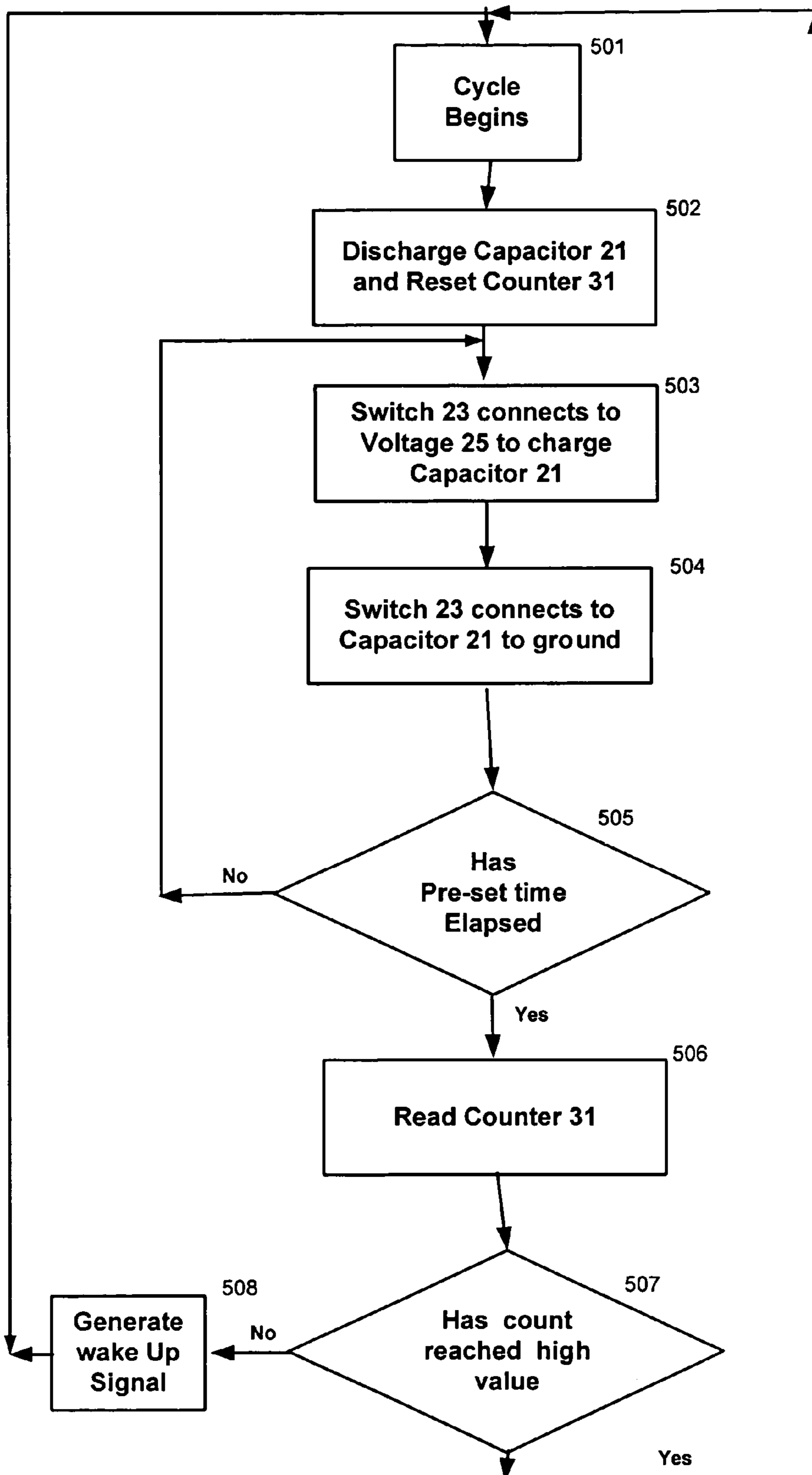


Figure 4

Step	Switch 23	
	Power	Discharge
Reset	0	1
Step 1	1	0
Step 2	0	1
Step 3	1	0
Step 4	0	1
Step 5	1	0
Step 6	0	1
Step 7	1	0
Step 8	0	1
Step 9	1	0
Step x	0	1



Figure 5





**1****TOUCH WAKE FOR ELECTRONIC DEVICES**

## FIELD OF THE INVENTION

The present invention relates to electronic devices and more particularly to a method and system for activating an electronic device.

## BACKGROUND

In many electronic devices there is a need to conserve power. In particular, in battery operated hand held devices, the amount of power available is limited. One technique, frequently used to conserve power, is to have a low power mode. Such a low power mode is frequently referred to as a "sleep mode".

Generally, when a device is in a sleep mode, many of the components in the device are deactivated. Only those components are active that are necessary so that the device can resume a fully operational state without any significant delay. Devices that have a sleep mode must have some mechanism to return the device to an operations state from the sleep power mode. Returning a device to an operational mode from a sleep mode is generally referred to as waking the device.

There are a variety of existing mechanisms for waking electronic devices from a sleep mode. The simplest is a mechanical switch or button, that when pressed, wakes the device. Other known devices include optical or mechanical motion sensors. Such motion sensors can, for example, be used to wake a battery operated wireless mouse when the mouse is moved.

Existing devices for waking hand help battery operated devices have a variety of disadvantages. For example, a button or switch requires a specific physical action on the part of the operator to press the button or switch. Many motion sensors require additional hardware. Finally, many of the existing devices consume what may be a significant amount of power for a very low power device.

Described below are an improved method, system and device for waking a hand held electronic device.

## SUMMARY

Described below is a system and method for generating a wakeup signal for a low power device such as a wireless mouse. With the system described herein, the device wakes up as soon as an operator touches it. The system includes a capacitor, the capacitance of which changes when a user touches the device. A metal strip (which is connected as one electrode of a capacitor) is positioned so that an operator seeking to use the device will touch the device in the vicinity of the metal strip; however, there can be a thin insulating layer (such as a mouse casing) between the metal strip and the surface that the operator touches. The value of the capacitance is periodically measured when said device is in a sleep mode. If it is determined that the value of the capacitance is relatively large, it means that an operator is touching the device and a wake up signal is generated. Thus, a wake signal is generated when the operator touches the device.

## BRIEF DESCRIPTION OF THE FIGURE

FIG. 1 is an overall diagram of a first embodiment.

FIGS. 2A, 2B and 2C shows the capacitor and switch in the first embodiment.

FIG. 3, shows the control logic for the switch.

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FIG. 4 is a table showing the state of the switch at various steps.

FIG. 5 is a flow diagram showing the operation of the first embodiment.

## DETAILED DESCRIPTION

Several preferred embodiments of the present invention will now be described with reference to the accompanying drawings. Various other embodiments of the invention are also possible and practical. This invention may be embodied in many different forms and the invention should not be construed as being limited to the embodiments set forth herein.

The figures listed above illustrate the preferred embodiments of the invention and the operation of such embodiments. In the figures, the size of the boxes is not intended to represent the size of the various physical components. Particular reference numeral is used to denote the same element in multiple figures.

Only those parts of the various units are shown and described which are necessary to convey an understanding of the embodiment to those skilled in the art. Those parts and elements not shown are conventional and known in the art.

FIG. 1 shows a wireless computer mouse **10** that is battery operated by a battery **12**. As is conventional, the mouse **10** has a plastic shell or casing **10A** and right and left buttons designated LB and RB in the figure. The mouse **10** includes conventional circuitry **13** that puts the mouse into a low power, sleep mode, when the mouse is not used for a pre-specified period of time. Such circuitry, that puts a device in a sleep mode, is conventional in devices where it is important to save battery power. In the normal wake mode, the mouse **10** generates radio signals to communicate with a host. In the sleep mode this transmitter is turned off, thereby conserving power.

Mouse **10** includes a special circuit **14**, described in detail below, which produces a signal to wake the mouse **10** when the mouse is merely touched by the user. The mouse **10** has a conductive strip **11** that activates the wakeup circuit in a manner that is described below.

It should be understood that, in other embodiments, device **10** could be a device other than a wireless mouse. For example device **10** could be a cell phone or a portable media player and the circuitry described below could be used to active the display or to turn on the backlight for a display.

The conductive pad **11** is positioned inside the mouse casing **10A** at a location where a user would normally place a finger on the casing when the device is being used. The mouse casing **10A** is a conventional plastic mouse casing that is about one millimeter thick. The conductive pad **11** functions as a capacitor the capacitance of which changes when a users finger touches the case as the location where the strip is located.

While this first embodiment includes a single conductive pad **11**, other embodiments include two or more such conductive pads at locations where a user is likely to place a finger when using the device.

The wakeup signaling circuitry in device **10** includes a capacitor and switch as shown in FIGS. 2A, 2B and 2C and control and logical circuitry as shown in FIG. 3. FIG. 4 is a flow diagram illustrating the operation of the device. Some of the basic principles of operation will first be described with references to FIGS. 2A, 2B and 2C and then, the actual operation of the system will be explained with reference to FIGS. 3 and 4.



FIGS. 2A, 2B and 2C, shown the variable capacitor 21 (which is formed by the conductive strip 11), a switch 23, a voltage supply 25, and a voltage measuring circuit 24.

Capacitor 21 is a variable capacitor, the capacitance of which is changed when the operator touches the mouse 11 at the location where pad 11 is located. The conductive strip 11 functions as a capacitor. When the operator's finger touches the mouse 10 at a location near the conductive strip 11, the value of capacitor 21 is increased.

The second electrode of capacitor 21 is effectively connected to ground 26 as illustrated in the figures. Switch 23 can connect the first electrode of capacitor 21 to either voltage source 25 or to ground 26. When capacitor 21 is connected to voltage source 25, it is charged and when it is connected to ground 26, it is discharged. It is noted that switch 23 is a conventional transistor switch.

In the specific embodiment described here, the voltage source 25 is a three-volt supply. The value of capacitor 21 depends on the size of the strip 11, and of importance to the operation of the circuit is the amount of change in capacitance when an operator touches the device near the strip 11. In the specific embodiment described here, the strip 11 is one inch long and a half inch wide and the casing 11A, which forms a dielectric for the capacitor is one-millimeter thick. With such a configuration, the capacitance of capacitor 21, is about doubled when the operator places a finger on the device. However, the exact capacitance is a matter of detailed engineering design.

It is noted that the values given above are merely nominal exemplary values. What is essential for the device to operate properly is that the capacitance of capacitor 21 significantly change when an operator places a finger on the device.

The device operates as follows: The first step is a reset step during which the capacitor 21 is discharged. Closing switch 23 connects both electrodes of capacitor 21 to ground 26 and discharges capacitor 21. FIG. 2A illustrates the circuit with switch 23 in a position to discharge the capacitor 21.

Next switch 23 is connected to the positive voltage 25. The circuit with switch 21 connected to voltage 25 is shown in FIG. 2B. When switch 23 is connected to the positive voltage 25, capacitor 21 is charged. The amount of charge that can be stored in capacitor 21 when switch 23 is connected to voltage 25, and thus the amount of time required to charge the capacitor to a pre-established value depends upon the size of capacitor 21. That is, more charge is stored on capacitor 21 and more time is required to charge capacitor 21, when the operator has a finger near strip 11, thereby increasing the capacitance of capacitor 21. Voltage detector 24 detects when the voltage on capacitor 21 reaches a pre-established value indicating that it is charged. For example if voltage supply 25 is a 3.3 volt supply, the pre-established value detected by circuit 24 could, for example, be three volts.

In the third step in the operation, the switch 23 is connected to ground 26. When this occurs, the capacitor 21 is discharged. Naturally, when capacitor 21 is in its high value state, more time will be required to discharge the capacitor. Circuit 24 detects when the capacitor 21 has been substantially fully discharged and the voltage at the terminal of the capacitor is substantially 0. What constitutes the exact fully discharged voltage is a matter of engineering design. In general it will be a voltage slightly above 0 volts.

After the capacitor 21 is discharged, switch 23 is re-connected to the voltage 25 as shown in FIG. 2B. When capacitor 21 is again charged the switch 23 is again switched to the position illustrated in FIG. 2C so that capacitor 21 can again be discharged.

The process is repeated many times, that is, switch 23 is moved between the positions shown in FIGS. 2B and 2C repeatedly for a fixed period of time. For example, the cycle may be repeated for 3 milliseconds.

The number of cycles that occur within the fixed period of time, indicates whether or not the operator's finger is located on the device, where conductive strip 11 is located.

The value of capacitor 21 is determined by whether or not an operator has a finger (or hand) near conductive strip 11. Thus, when the operator has a finger or hand near conductive strip 11, capacitor 21 has a relatively high value of capacitance, and less cycles occur during the fixed time period.

By counting the number of cycles that occur in the fixed period of time, the system can determine whether or not, the operator has a finger touching conductive strip 11. If device 10 is in a low power sleep mode, and the system determines that the operator has placed a finger on conductive strip 11, a wake up signal is generated.

The circuitry that controls switch 23 is shown in FIG. 3. It includes a counter 31, state machine and control logic 32 and a clock 33. The state machine control logic 32 has an output that control switch 23 and an output for the wakeup signal. This wake up signal goes to conventional wake up logic.

The table in FIG. 4 shows the cycles through which the circuit operates under control of state machine and control logic 32. The logical circuitry and the state machine in circuit 32 are conventional. The table in FIG. 4 has three columns. The first column indicates a step of the state of state machine in unit 32. There are two columns for switch 23. The first column under switch 23 indicates when the switch 23 is connected to the power source 25. A "1" in the first column under switch 23 indicates that switch 23 is connected to the voltage source 25 and it is thereby charging capacitor 21. A "0" in the first column under switch 23 indicates that switch 23 is not connected to the voltage source 25.

The second column under switch 23 indicates whether or not switch 23 is connected to ground 26. A "1" in the second column under switch 23 indicates that switch 23 is connected to ground 26 and that charge can flow from capacitor 21 to ground to discharge the capacitor. A "0" in the second column under switch 23 indicates switch 23 is not connected to ground 26.

A cycle begins with a reset step (indicated by the first line of the table in FIG. 4). During this step capacitor 21 is discharged.

Next there are a series of steps indicated as steps: "1" to "x" in FIG. 4 during switch 23 alternates between being connected to voltage source 25 and being connected to capacitor 22. During each of these steps, capacitor 21 is first charged and then the charge on capacitor 21 is transferred to ground 26.

Detector 24 detects when the capacitor 21 is fully charged, and this terminates each charging step. Detector 24 also detects when capacitor 21 is discharged and this terminates each discharge step. Counter 21 counts the number of steps or cycles that occur during a pre-set amount of time indicated by clock circuit 33. If the number of cycles counted by counter 21 in the preset time interval is relatively small, it indicates that the value of capacitor 21 is relatively large. This means that the operator's finger is on or near pad 11. If the number of cycles counted by counter 21 is relatively large, it means that the value of capacitor 21 is relatively small and that the operator's finger is not near the pad 11.

In the preferred embodiment, the capacitance of pad 11 is checked three times every second. Each check requires about 3 microseconds. Thus, when the mouse is in sleep mode, the



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circuitry is only active for about nine microseconds in each second. When the mouse is not in sleep mode, no checks are made.

FIG. 5 is a flow diagram showing the operation of the circuit. The operation is continuous and as indicated above, a new cycle is initiated every one third of a second. That is, there are three cycles per second. Clock circuit 33 controls this in a conventional manner. Block 501 indicates the beginning of a cycle. As indicated by block 502, as a preliminary step, switch 23 is connected to ground 26 to discharge capacitor 21. The switch 24 is closed for a period of time sufficient to discharge capacitor 21. During this reset step counter 31 is also set to zero.

Next as indicated by block 503, switch 23 is connected to voltage source 25. This allows capacitor 21 to charge. The switch is connected to voltage source 25 for a sufficient time to allow capacitor 21 to essentially fully charge. Detector 24 determines when the capacitor is fully charged. When detector 24 determines that the capacitor is fully charged, the process moves on to the next step.

Switch 23 is next connected to ground 26 as indicated by block 504. This transfers the charge from capacitor 21 to ground and discharges the capacitor. Again the switch is left connected to capacitor 22 for an amount of time determined by detector 24. That is, detector 24 determines when capacitor 21 has been discharged and the system can move on to the next step.

A test is then made (by circuit 32) to determine if a pre-specified time has expired. If the time has not expired, the process returns to block 503. If the time has expired, counter 31 is read as indicated by block 506. As indicated by block 507, a test is made to determine if the counter has reached a pre-established high value. If the counter has reached a high value the process returns to block 501 because this means that the operator has not touched the device.

If the count in counter 31 is relatively low, it means that the operator has touched the device near strip 11, and a wake up signal is generated as indicated by block 508.

As an example, the difference in the count between when an operator has a finger or hand near the area whether step 11 is located and when no hand is present may be the difference between a count of 100 and 200 if the capacitance is doubled by the presence of a hand.

It is noted that herein the term "operator's finger is used to mean any part of the operator's hand. Thus, the term operator's finger means any part of the operator's hand that is placed on the device 10 in the vicinity of strip 11. The wake up signal is generated by the above circuit when any part of the operator's body is placed on device 10 in the vicinity of strip 11. As used herein, an operator touches a device by placing any part of a hand on the device in the vicinity of strip 11 or in other embodiments with multiple strips, in the vicinity of any one of the strips.

The embodiment described above utilizes a particular method of determining the capacitance. It is noted that in other embodiments, other techniques for measuring capacitance are used.

While the invention has been shown and described with respect to preferred embodiments thereof, it should be understood that a wide variety of other embodiments are possible without departing from the scope and spirit of the invention. The scope of the invention is only limited by the appended claims.

We claim:

1. A system comprising:

a capacitance measurement circuit that includes only one capacitance sensor, wherein the capacitance sensor

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comprises a first conductive strip positioned adjacent to an interior surface of a casing of a device, beneath an area of an external surface of the casing touched by a user, wherein the conductive strip forms a capacitor, a capacitance of which is increased when the user touches the exterior surface of the casing;

a switch coupled to the capacitor, the switch to alternately couple the capacitor to a voltage source to charge the capacitor and to a ground supply to discharge the capacitor;

a detector circuit coupled to the capacitor, the detector circuit to determine when the capacitor reaches a pre-set charge and when the capacitor is fully discharged;

a control circuit coupled to the detector circuit, the control circuit responsive to the detector circuit to alter a position of the switch, wherein the position is altered when the capacitor reaches the pre-set charge and when the capacitor is fully discharged;

a counter coupled to the control circuit, the counter to count a number of times the position of the switch is altered in a pre-established period of time and compare the number of times the position of the switch is altered to a pre-established count value; and

a signal generator circuit coupled to the counter, the signal generator circuit to generate a signal to wake the device from a sleep state if the number of times the position of the switch is altered does not match the pre-established count value during the pre-established period of time.

2. The system of claim 1, wherein the number of times the position of the switch is altered is inversely related to the capacitance of the capacitor.

3. The system of claim 1, wherein the device is battery operated.

4. The system of claim 3, wherein the device is a computer mouse.

5. The system of claim 1, wherein the casing comprises a non-conductive material.

6. The system of claim 5, wherein the casing comprises a dielectric for the capacitor.

7. The system of claim 1, wherein the pre-set charge is a charge that generates a voltage of approximately three volts.

8. The system of claim 1, wherein fully discharged comprises a voltage of approximately zero volts.

9. The system of claim 1, wherein the control circuit comprises a clock and a state machine.

10. A method of generating a wakeup signal for a device, the method comprising:

sensing, by a capacitance measurement circuit, a capacitance value, wherein the capacitance measurement circuit includes only capacitance sensor, wherein the capacitance sensor comprises a first conductive strip located adjacent to an interior surface of a casing of the device, wherein the conductive strip forms a capacitor; changing a capacitance value of the capacitor from a relatively low value to a relatively high value when a user touches an exterior surface of the casing;

alternately charging the capacitor to a pre-set charge and fully discharging the capacitor;

counting a number of cycles for the capacitance value to reach the pre-set charge and to be fully discharged in a pre-established period of time and comparing the number of cycles to a pre-established count value; and

generating the wakeup signal for the device if the number of cycles does not match the pre-established count value during the pre-established period of time.

11. The method of claim 10, wherein the number of cycles is inversely related to the capacitance value of the capacitor.



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**12.** The method of claim **10**, wherein charging the capacitor comprises setting a position of a switch to couple the capacitor to a voltage source.

**13.** The method of claim **12**, wherein discharging the capacitor comprises altering the position of the switch to couple the capacitor to a ground supply.

**14.** The method of claim **13**, further comprising:  
altering the position of the switch when the capacitance value reaches the pre-set charge and when the capacitor is fully discharged.

**15.** The method of claim **10**, wherein the device is a battery operated wireless computer mouse which goes into a sleep state when not moved for a particular period of time.

**16.** The method of claim **10**, wherein the casing comprises a non-conductive material.

**17.** A system comprising:  
a capacitance measurement circuit that includes conductive means forming only one capacitor, wherein the conductive means are positioned adjacent to an interior sur-

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face of a casing of a device, and wherein a capacitance value of the conductive means is increased from a relatively low value to a relatively high value when the user touches an exterior surface of the casing of the device;

counting means coupled to the conductive means, the counting means for determining a number of cycles where the capacitor is charged to a pre-set charge and is fully discharged in a pre-established period of time and comparing the number of cycles to a pre-established count value; and

circuit means coupled to the counting means, the circuit means for generating a signal to wake the device from a sleep state if the number of cycles does not match the pre-established count value, and if the capacitor has a relatively high value.

**18.** The system of claim **17**, wherein the number of cycles is inversely related to the capacitance value of the capacitor.

\* \* \* \* \*